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ASPECTS OF HYDRAULIC ENGINEERING IN MEDIEVAL RAJASTHAN: A CASE STUDY OF WATER-SYSTEM IN JAIGARH FORT*

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[See Pls.XLII-XLVII and Figs.2-6]

To the North-East of the city of Jaipur and beyond the Amber palace, on the spurs of the Aravali range, is situated the fort of Jaigarh. It was the capital of the Kachhwaha rulers of Amber since their victory over the powerful local tribe, the Minas (13th century). From the two plans of the fort, preserved in the City Palace Museum,Jaipur, it appears that Sawai Jai Singh (1698-1740), before shifting his capital to his newly planned city (A.D. 1727), carried out major repair and remodelling of this fort (Pl.XLIIa). Strategically located, the Jaigarh fort could monitor the defensive and offensive requirements of the ruler, if such contingencies arose. Being situated on top of a hillock about 2000 feet high (Fig.2), and having all the basic characteristics of a hill fort (*giri durg*), the most peculiar feature of this fort appears to be its hydraulic system which would not only have added to its basic strength, but also took care of its daily needs. Interestingly, striking similarities appear between the hydraulic systems of the ancient Roman and Palestinian forts situated in the *wadi* and that of the Jaigarh Fort, that is, one finds water-channels and ducts built all along the mountainous terrain outside the precincts of the fortification, conducting water during the spate of rains into the reservoirs and tanks constructed inside the fort.[2]

The present study is based on a physical survey of the terrain carried out by the authors in the autumn of 1991. It attempts to highlight some aspects of the water-supply system of the Jaigarh Fort which, surprisingly, has by and large escaped the notice of scholars.[3]

The network of the water-channel commence on the hillocks and starting from the south, form three loops before entering into the fort walls (Fig.3). These loops around the hillocks are formed in such a manner that the rain-water falling on the hills is not allowed to drain down, but is collected in these channels to be directed towards the fort due to gravity flow.

The course of the channels start from a hillock, situated at a distance of 3.5 km from the southern ramparts of the Jaigarh Fort, which is aligned in N-W and S-E direction. It is here that presently a radio station islocated. This hillock is surrounded by water ducts forming an elliptical circle, around a kilometre in length. From here the water is directed through a channel towards the west to an acquaduct (Pl.XLIIb) raised on five bastions and thirty-nine arches (of which only one is open); the others being closed at some point of time with rubble stones (Pl.XLIII-XLIVa). This acquaduct carried the water from one hillock to the other avoiding the otherwise sudden dip between the hills. The point, from where this acquaduct commences, is constructed as a rectangular platform which was possibly meant to accommodate the person responsible to regulate the flow of water. At this junction, the acquaduct is 3 m wide, which then gradually tapers off to 1.33 m only, which is the general width of the channels.

After a distance of 330 m, the channel bifurcates into two ducts forming a second loop around the hillock. These two ducts rejoin each other at a distance of 500 m, immediately to separate once again to form an irregular third loop. At all the points where the western

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and the eastern channels join, a triangular shape is given to allow easy flow of water without causing any erosion or damage to the embankment or the floor of the ducts. Small cisterns (*kundi*) have also been provided for at these junctions. The western duct zigzags for another 500 m where a rectangular recess measuring 1.89 x 1.48 m is constructed. From here the duct turns gradually towards the east and, forming a semi-circle, joins the eastern duct.

The eastern duct from its very start takes an easterly tilt, correcting its course only twice by 25° towards the north. Just before being joined by the western duct, the eastern duct zigzags into seven sharp bends. Interestingly, all along their route the channels change direction through sharp angular instead of gradual curves (Pl.XLIVb). Possibly this was done to block the flow of the debris from the hills along with the water. One also finds that the western ducts mostly are situated at a higher level than these situated on the east. The eastern ducts are also not provided with any acquaduct-bridge. Possibly this meant that in case of a light downpour, the water being collected through the western ducts, could be diverted into the eastern ducts which were at a lower altitude, and, from there be carried inside the fort. This point is further stressed by the fact that the western ducts are perfectly horizontal without any inclinations in their floor-levels, whereas the eastern channels and ducts are provided with gradual depreciations in the floor levels. In case of a heavy downpour, both the ducts would have been under direct use to take the water inside the fort. From the point of the junction of the western and the eastern ducts, starts an east-oriented 1.83 m wide and 330 m long channel which ends near the southern ramparts of the fort where presently the Jaivana is located (Pl. XLVa). From here, the water is allowed to fall into a rectangular opening provided in the floor, which takes the water inside the ramparts through a subterranean channel. This opening is now provided with a heavy iron grill. On entering into the fort-wall, the water is directed (Fig.4) into a 29.5 m long channel which has a floor inclining upwards around 25°. This upward inclination facilitates the settling of the debris from the water brought from the hills. This passage (Pl.XLVb) is 1.7 m wide and has a depth of 3 m near the fort wall and 1.7 m at its end. On both its sides, it is provided with embankments which are 0.76 m thick. From here the water, if found clear, is carried, by opening a sluice gate (Pl.XLVIa), through an underground channel to the central tanks of the fort. If not, the water could be diverted into a half finished[4] open tank (Pl. XLVIb), popularly known as *Nathawaton ka tanka*, which was presumably meant for the needs of the animals being maintained inside the fort[5].

The covered subterranean channel veers its way through the second gate of the fort, and from there onwards it is again in the open. This channel leads the water into a rectangular cistern having two sluiced openings. Through the one, the water can directly enter into a large water reservoir, popularly known as *tanka* which is wholly covered from above (Pl.XLVIIa). Built in a square shape, with each side measuring 47.4 m[6], it is approximately 12 m deep and has a capacity to hold 60,00,000 gallons of water.[7] The ceiling of this *tanka* rests on 81 arched pillars (Fig.5). On top of the ceiling and exactly in its middle, is constructed a square platform with an opening. Towards the north, a couple of staircases descend below where a walkway/ramp is provided to draw water. These staircases can be approached through doors constructed towards the east and west.

If the water is not required to be stored into this large reservoir, the channel, through the second sluice of the cistern, leads it to a rectangular open tank measuring 18.30 x 15.6 x 8.10 m. This tank, popularly known as the bathing tank, is also provided with a flight of steps (towards the south) leading down below (Pl. XLVIIb).

Adjoining this open tank towards the south, is the third tank which, like the *tanka*, is

covered with a roof. It measures 20.7 x 15.6 x 15.6 m, and is provided with nine holes (wells) on its ceiling to facilitate lifting of water from it. The surplus water from the open tank was carried into this covered tank with the help of circular sluices provided for high above on the adjoining wall. This meant that only clear water would be carried into the third tank.

As far as the building material is concerned, one finds that all the ducts and channels are constructed with the help of rubble-stone, heavily plastered with lime-mortar. The tanks and reservoirs are also constructed with the help of rubble-stone and lime-mortar.

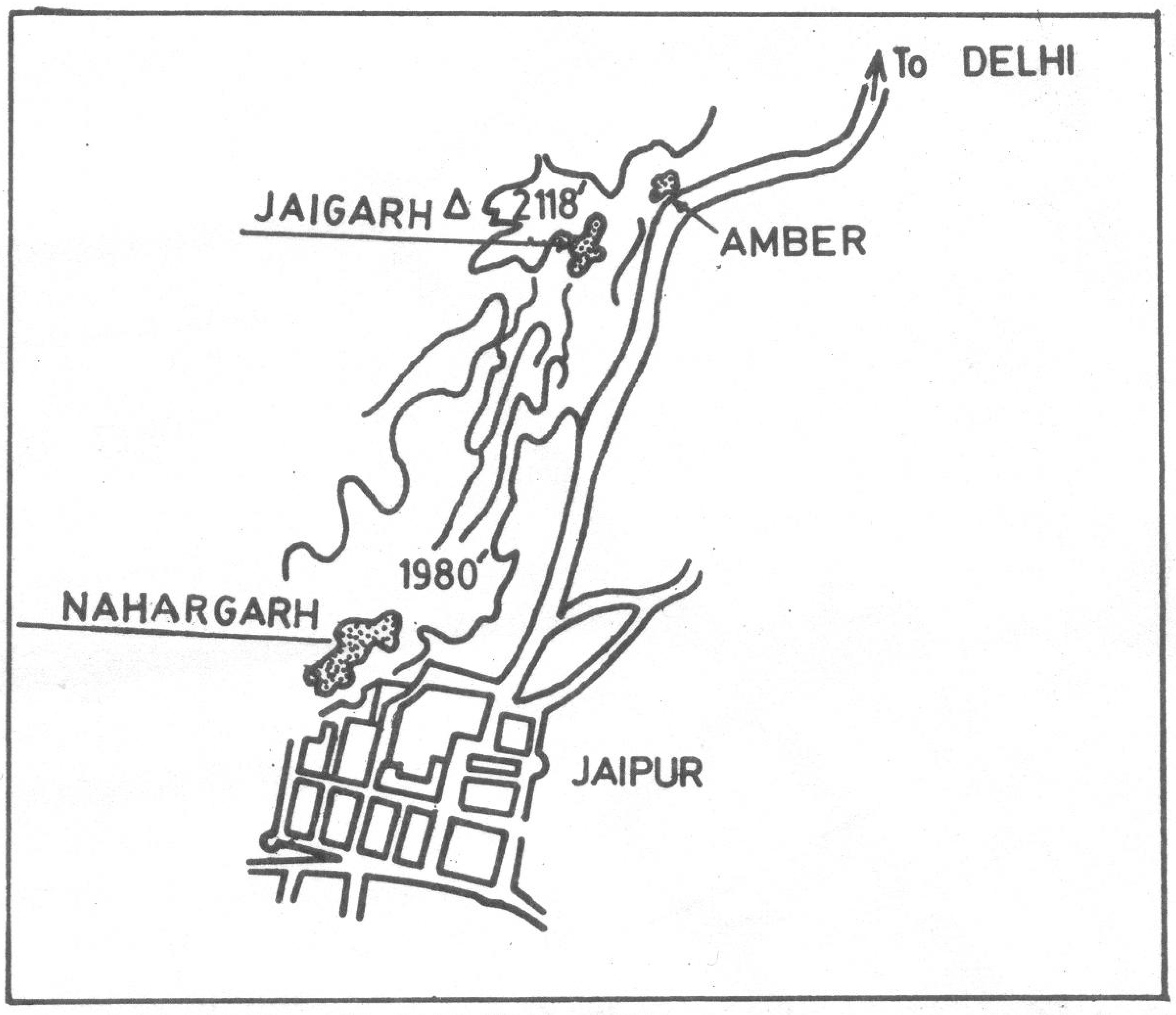
While laying the duct bed, enough care appears to have been taken towards sophistication and water-proofing. At the very bottom was laid a stone pavement of heavy rubble which was then covered with a layer of small chipped stone pieces, and subsequently plastered over with a heavy paste of gravel and lime (Fig.6). The side of the channel towards the slope of the hill is provided with embankments about 0.88 m thick, while the side towards the hill is provided with very narrow and slightly raised cornices having spaces to allow entry of water, and to block the passage of rubble into the channel. This provision along with a slight tilt of the channel bed towards itself ensured minimum loss of water. The easy flow of water was further ensured by building small and medium-size cisterns at all points where the ducts join or separate from each other. The debris being carried with water along the channel would settle in these cisterns which could be cleaned at a later stage. The ingenuity of constructing underground and covered water-tanks had its own effects. Through this, minimum water was lost by evaporation. Secondly, the water being stored could be kept unpolluted for a long time. Lastly, the water thus preserved, remained cool due to the thermostat effect of the air trapped inside the tank covered with a roof. The windows provided for in the *tanka* acted as ventilators to clear it of stale air and provide some amount of sunlight to enter into the tanks.

It was through this ingenious technique of captivating the rain-water on the hills and then directing it to the fort, that the Jaigarh Fort was equipped to withstand a long siege. This technique also solved the problem of carrying water from the lakes situated far below the hillocks. Their efficiency can be gauged from the fact that even in present times, during the rainy season, the water is carried through the same dilapidated and uncared for channels and viaducts. The water is still drawn from the *tanka* to cater to the needs of the tourists and the inhabitants of the fort.

Though not an isolated case, still Jaigarh is a fine example of hydraulic engineering of medieval Rajasthan.

NOTES

1. Susan Gole, *Indian Maps and Plans, from Earliest Times to the Advent of European Survey*, New Delhi, 1989, pp.191, 193; R.S. Khangarot and P.S. Nathawat, *Jaigarh - the Invincible Fort of Amber*, Jaipur, 1991, pp.15-16. Perhaps it was renamed Jaigarh during the reign of Sawai Jai Singh, for in earlier references it has been referred to as Amber, and prior to that as *Chil ka tola*.
2. For a description of the acquaducts and channels in old Roman and Palestinian settlements, see A *History of Technology*, ed. Charles Singer, E.J. Holmyard, A.R. Hall and Trevor I. Williams, Vol. I, Oxford, 1967, Chapter 19.
3. Khangarot and Nathawat, op.cit., only briefly mention the presence of acquaducts conducting rain-water to the reservoirs into the fort.
4. See the details of the plan of Jaigarh Fort preserved in the City Palace Museum, Jaipur (reproduced in Susan Gole, op.cit., pp.191-3, pls. 104, 106). From this map it becomes evident that Sawai Jai Singh had ordered its construction.
5. This information was supplied to us by Mr.Ram Avtar Singh, Administrator of the Fort. According to him, this practice of watering the animals continued till very recently.
6. Khangarot and Nathawat, , p.62, wrongly mention the width of the *tanka* as 138 feet.
7. The volume of the tank works out at 26961.12 cubic meters (volume = length x breadth x depth). As 1 cu.m holds 1000 litres of water, the total capacity of the tank is 26961120 litres. We know that 4.5 lts. = 1 gallon, thus it works out to 5991360 gallons (or 60,00,000 gallons).



LOCATION OF JAIGARH FORT

Fig.2

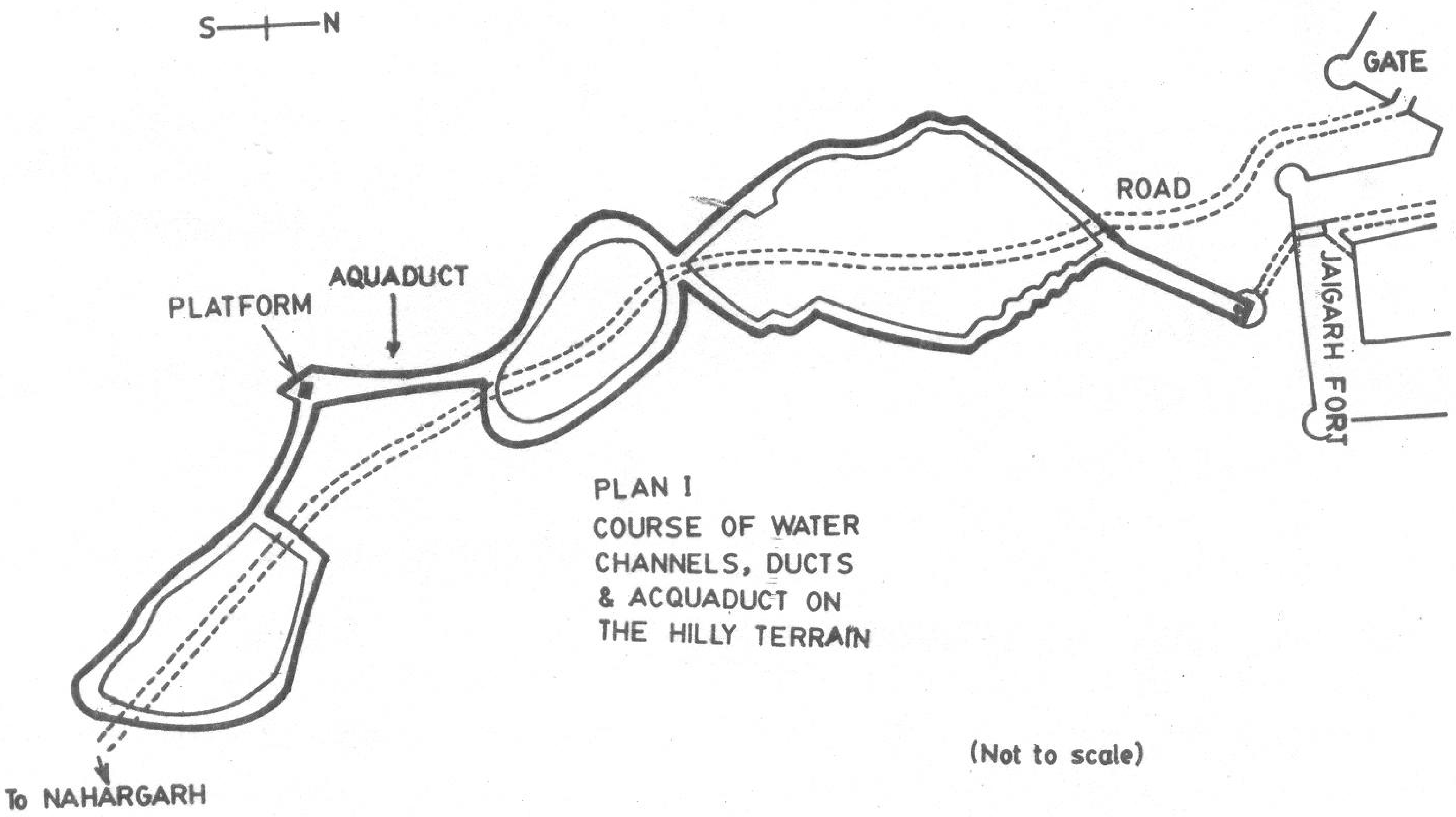


Fig.3

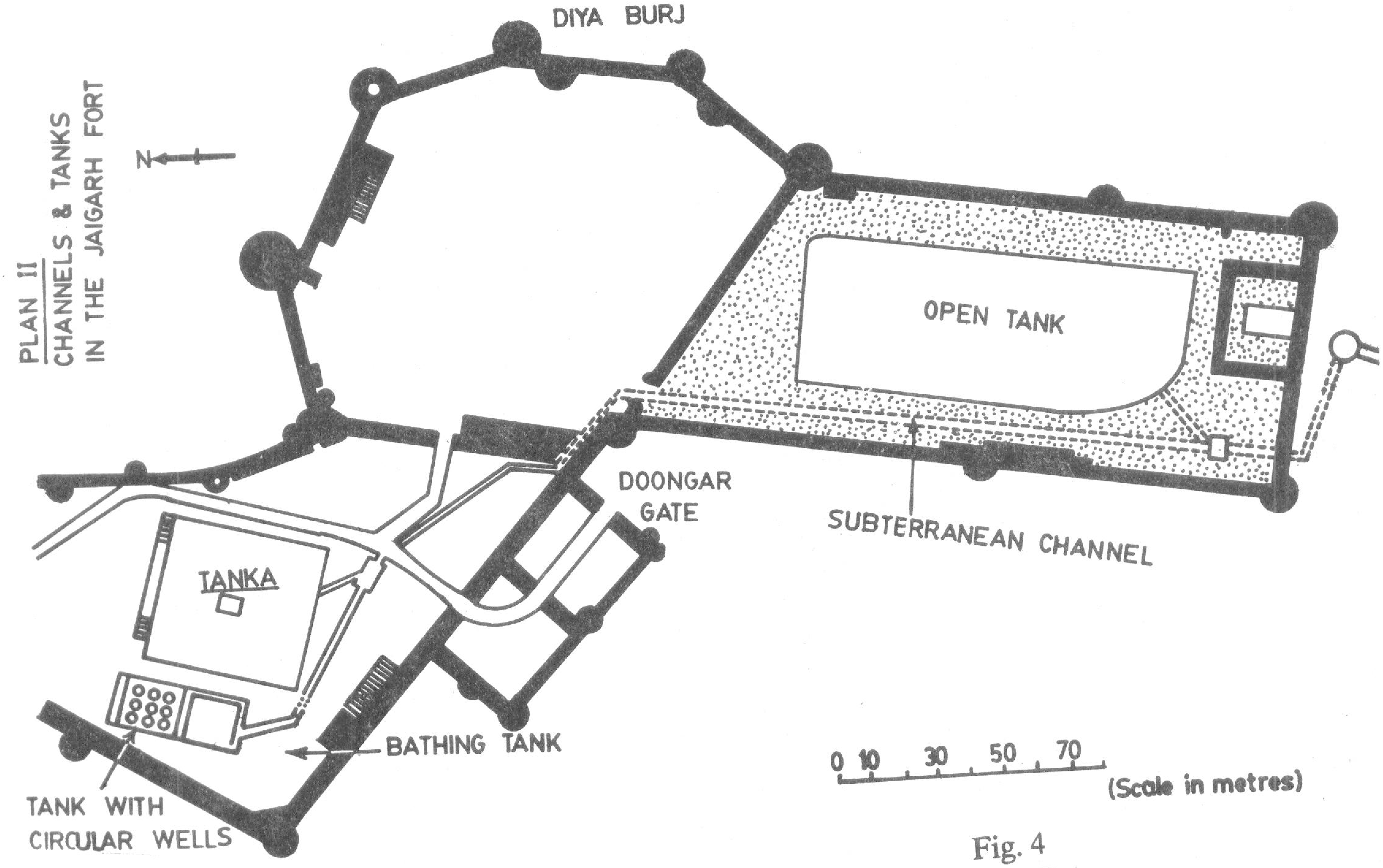
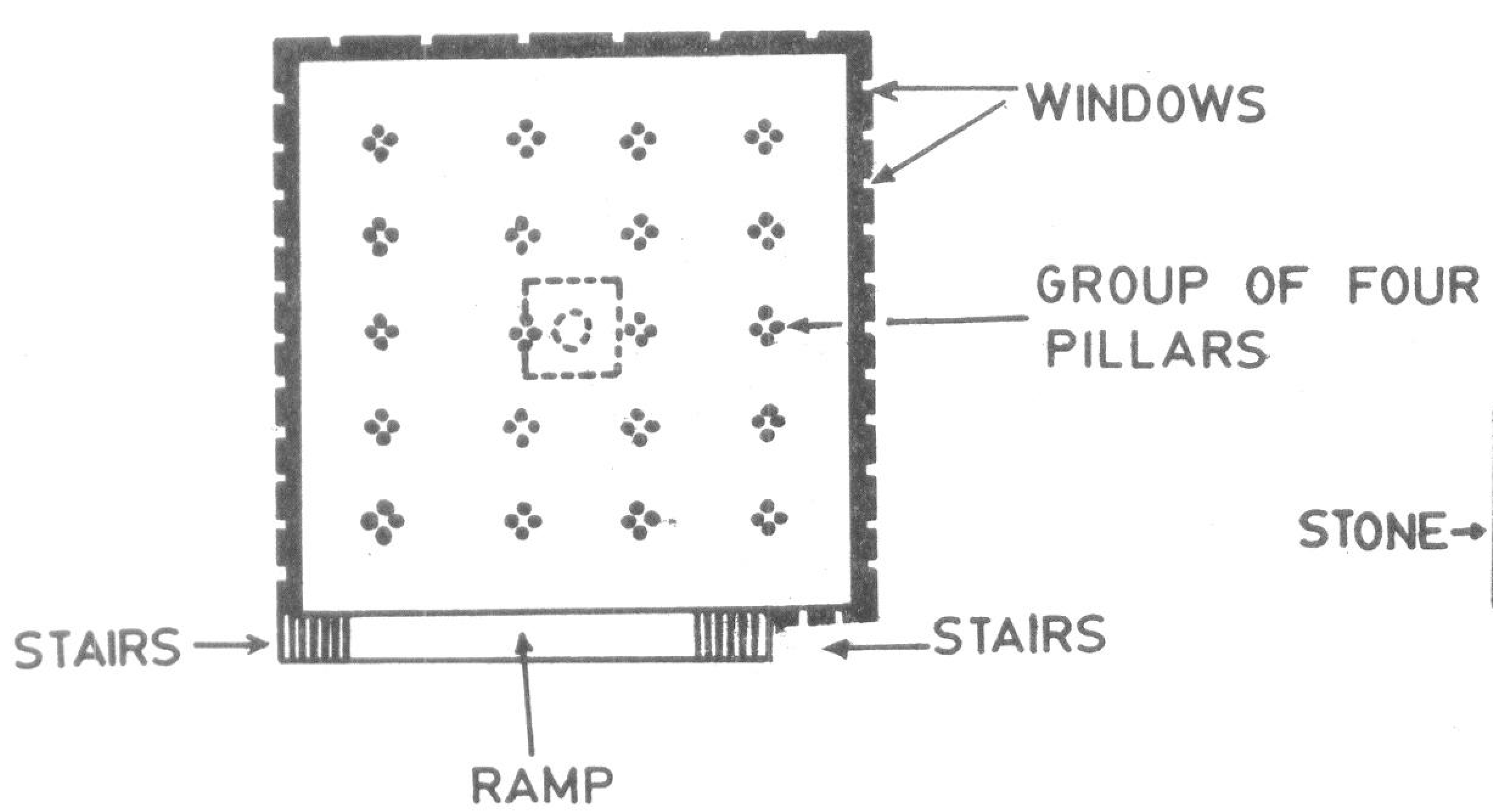
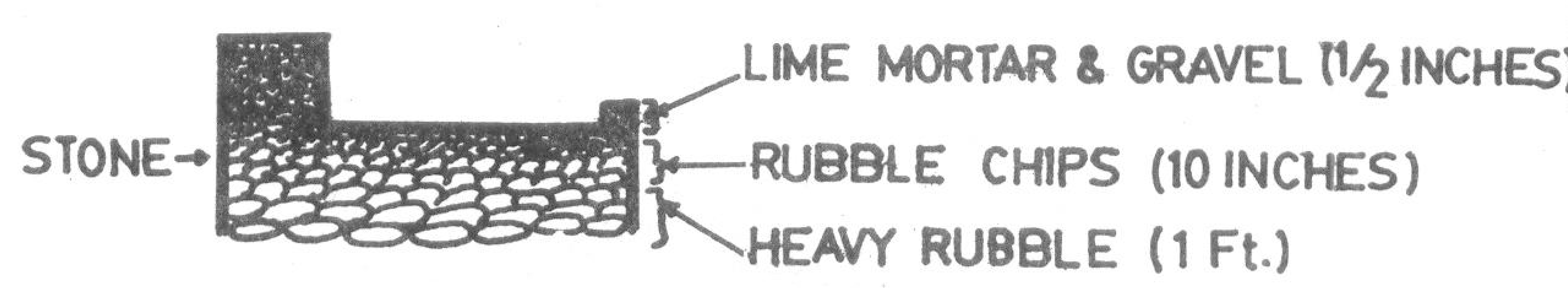


Fig. 4



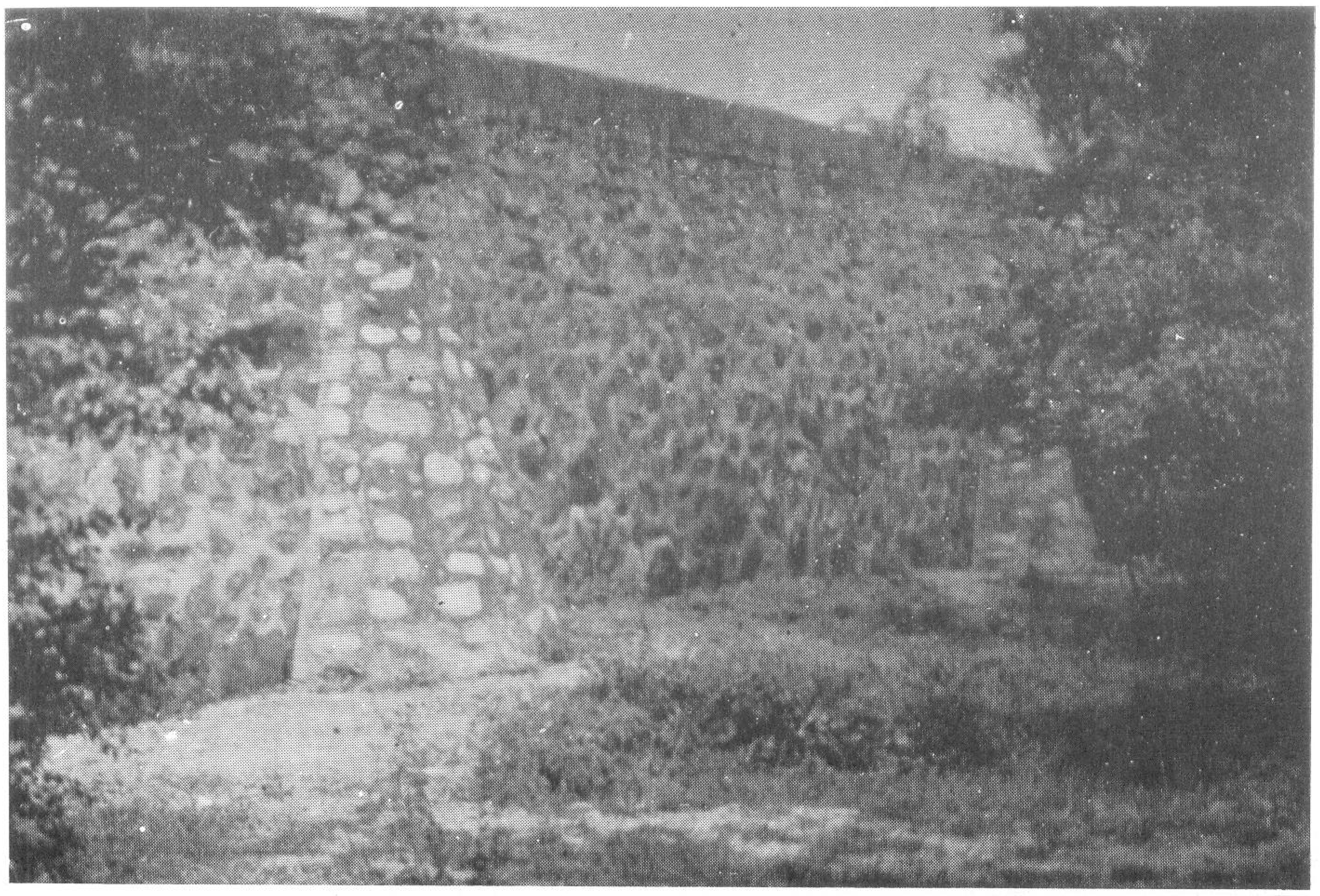
GROUND PLAN OF THE BIG RESERVOIR (TANKA)

Fig. 5



CROSS-SECTION OF A CHANNEL BED

Fig. 6



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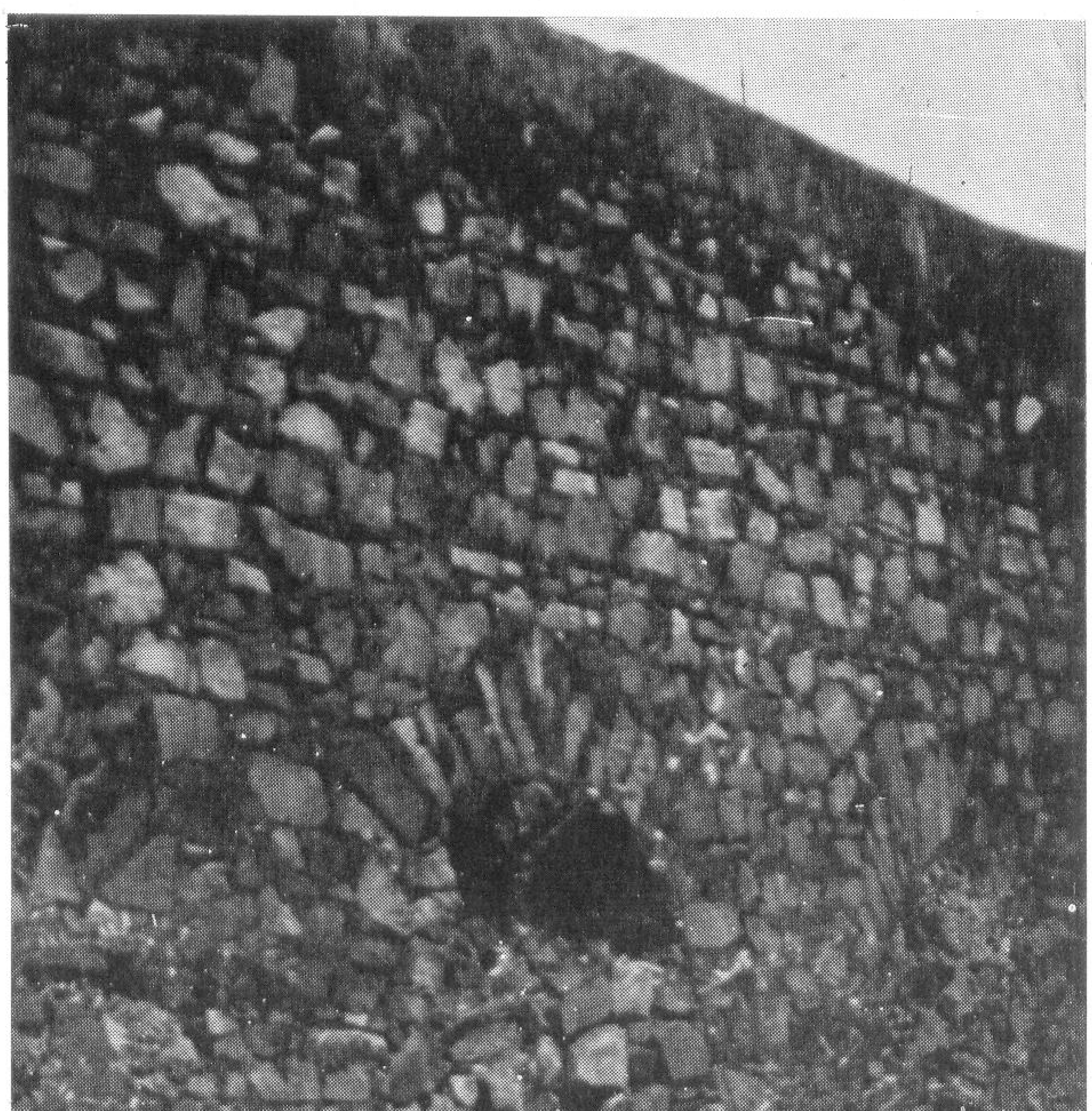

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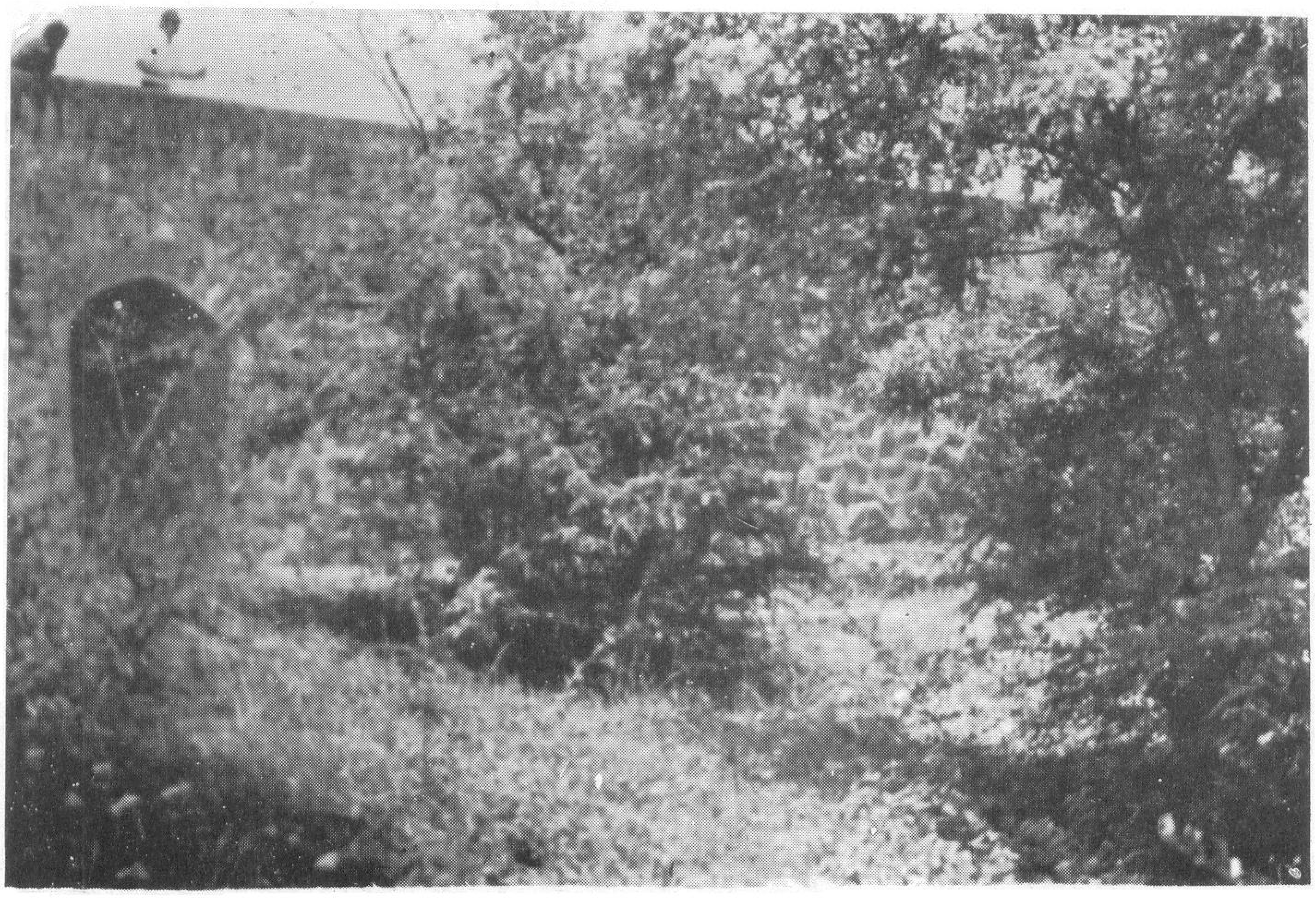

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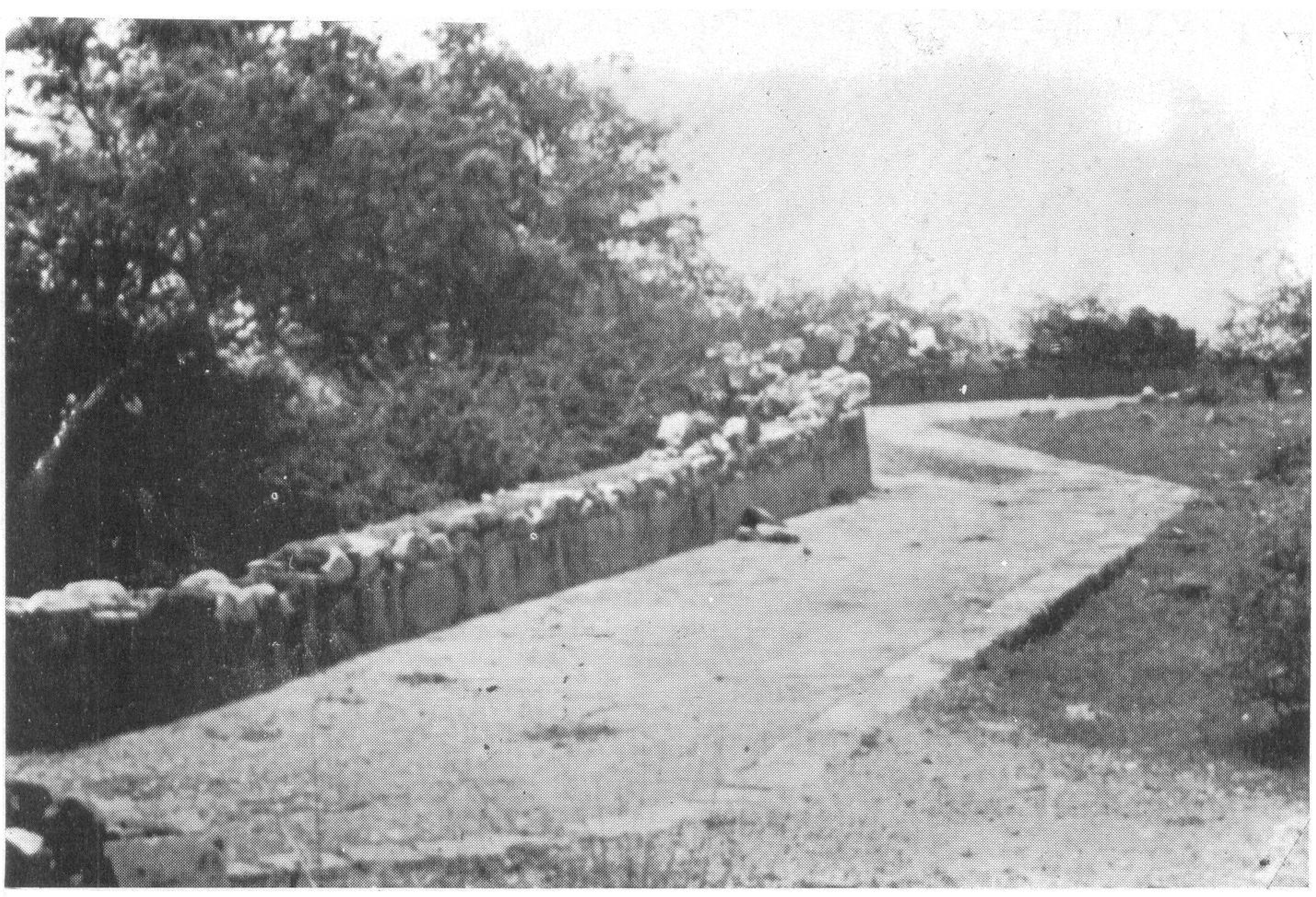

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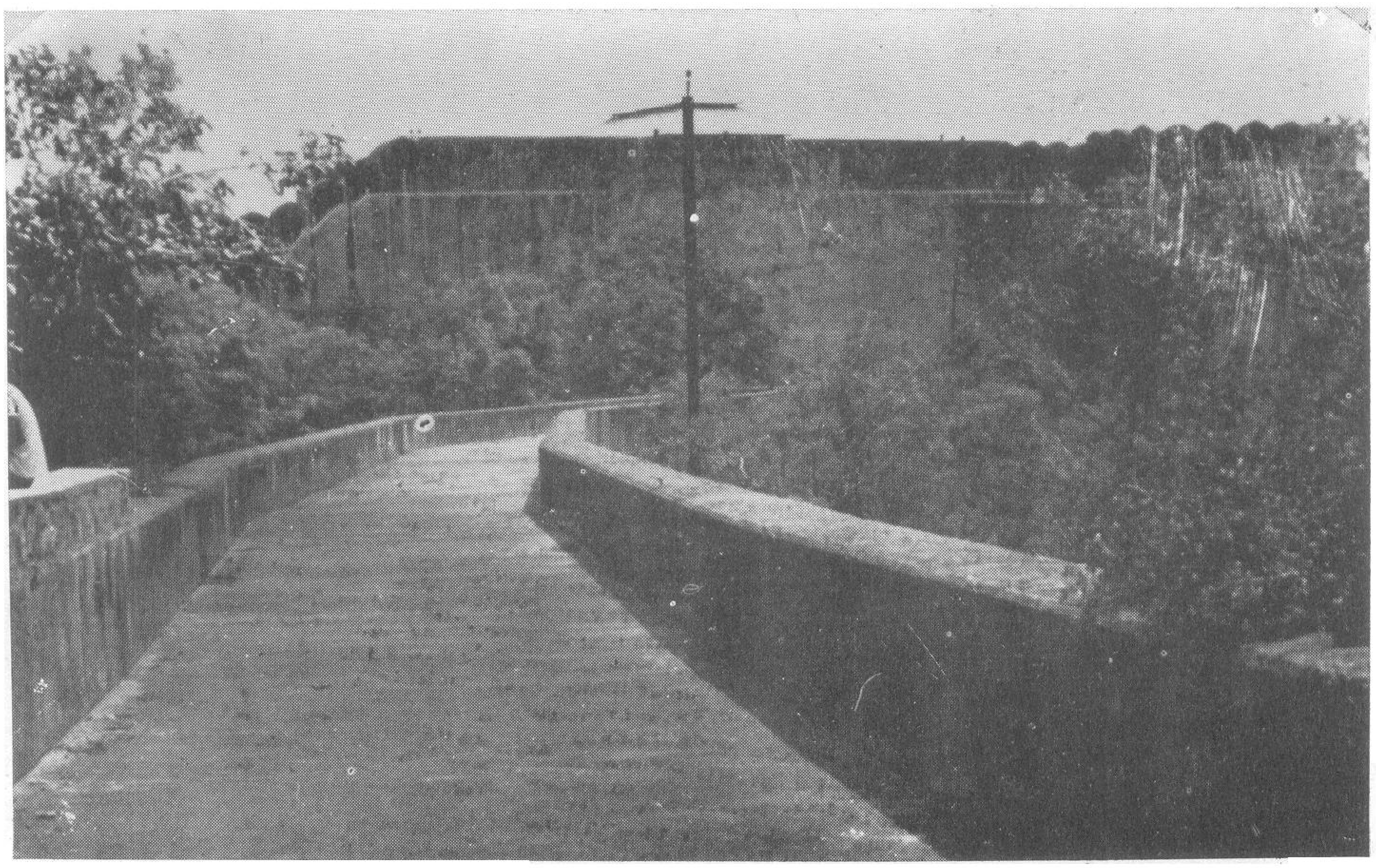

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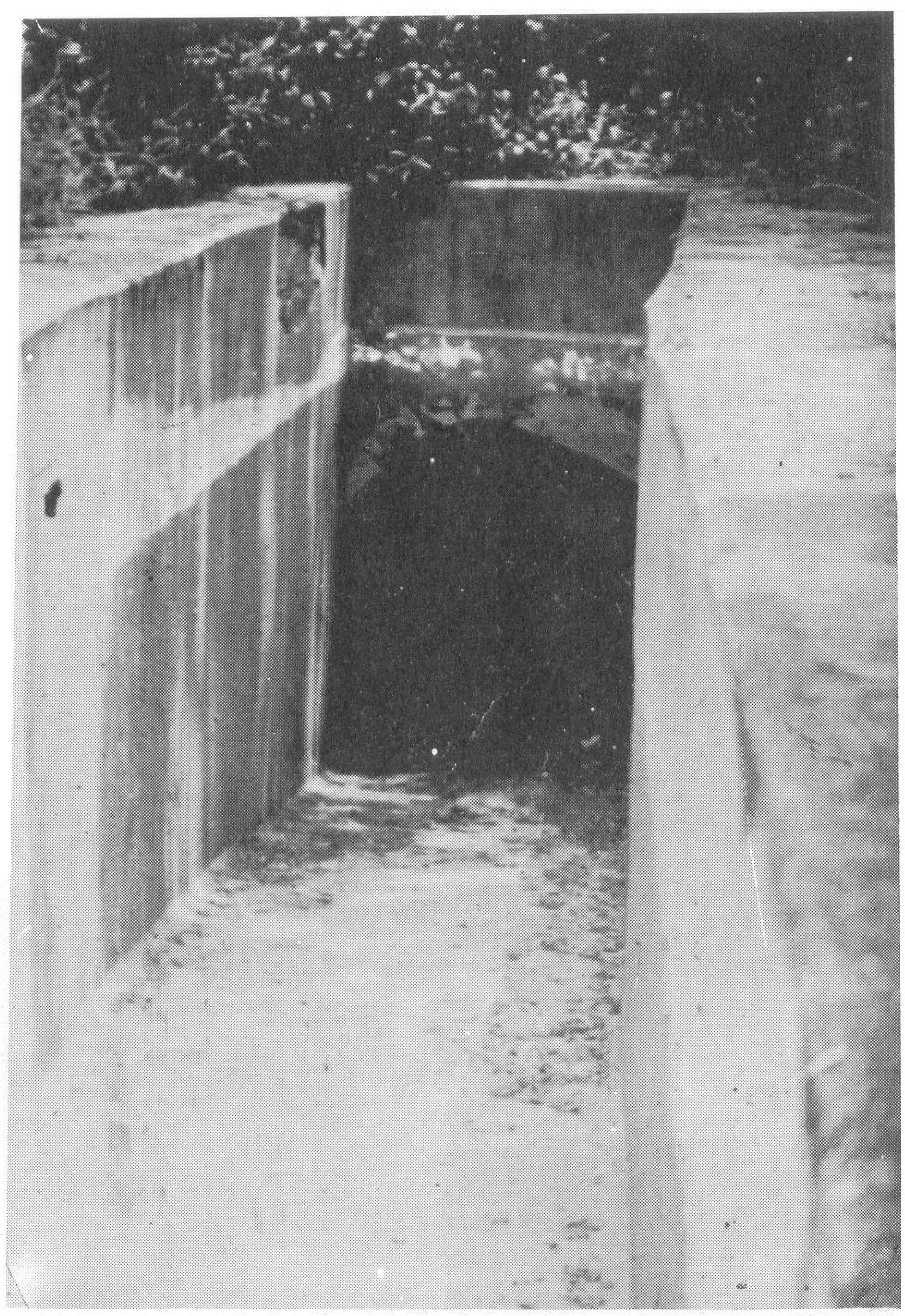

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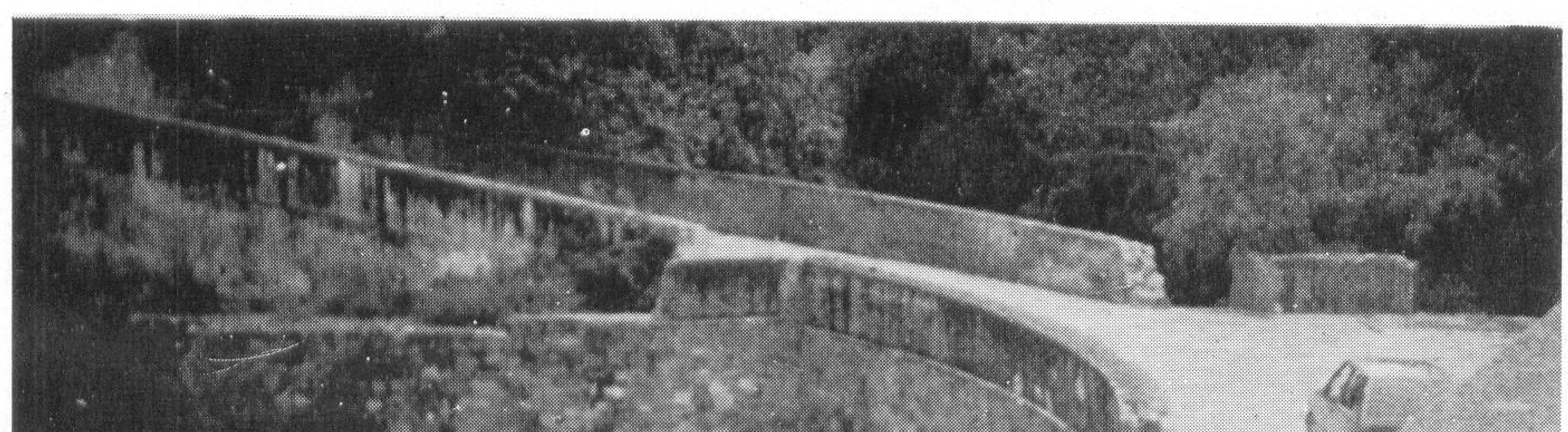

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